RADAR DEVELOPMENT KIT
USER'S MANUAL

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The Radar Development Kit is not classified for outdoor use. Users that use the product outdoors or in wet environments do so at their own risk. Sivers IMA takes no responsibility or gives any compensation for damages resulting from outdoor usage or from contact with water

CONTENTS

GENERAL

PRODUCT INFORMATION

Sivers IMA's Radar Development Kit (RDK) is intended for customers who want to either quickly evaluate the possibilities of FMCW radar or cost efficiently implement the features of FMCW radar sensors in their products.

The kit consists of a small case with a 24 GHz FMCW radar (Sivers IMA RS3400K), integrated antenna and a microprocessor board for controlling the radar and signal processing of the received echo signal for excellent accuracy and range resolution. At the bottom there is a bracket suitable for a camera tripod. The RDK comes bundled with a GUI that can be used for evaluating the radar and for configuring e.g. detection thresholds and distance. Different applications usually require different settings. Some typical applications are level measurements in tanks and security in the automation industry.

OPERATING CONDITIONS AND MAXIMUM RATINGS

Table 1 Operating conditions and maximum ratings.

Parameter	Min	Max	Unit
Digital input voltage (DI0 – DI1)	0	3.3	V
Digital input current (DI0 – DI1)	0	9	mA
Digital output voltage (DO0 – DO3)	0	3.3	V
Digital output current (DO0 – DO3)	0	15	mA
Analog output voltage (AO0 – AO1)	0	3.3	V
Analog output current (AO0 – AO1)	0	15	mA
12 V Power supply	0	12	V
Operating temperature	0	70	° C
Output power (EIRP)	-	25	dBm

The Radar Unit is enclosed in a tightly sealed housing making it suitable for outdoor use for short periods of time. However, note that the product is not classified for outdoor use. Hence, users that use the product outdoors or in wet environments do so at their own risk. Sivers IMA takes no responsibility or gives any compensation for damages resulting from outdoor usage or from contact with water.

GETTING STARTED

INCLUDED IN THE PACKAGE

- Radar Unit
- USB cable
- Power adapter

Figure 1 Radar Unit, USB cable and power adapter. At the bottom is a bracket suitable for a camera tripod.

HARDWARE

CONNECTING THE RADAR UNIT

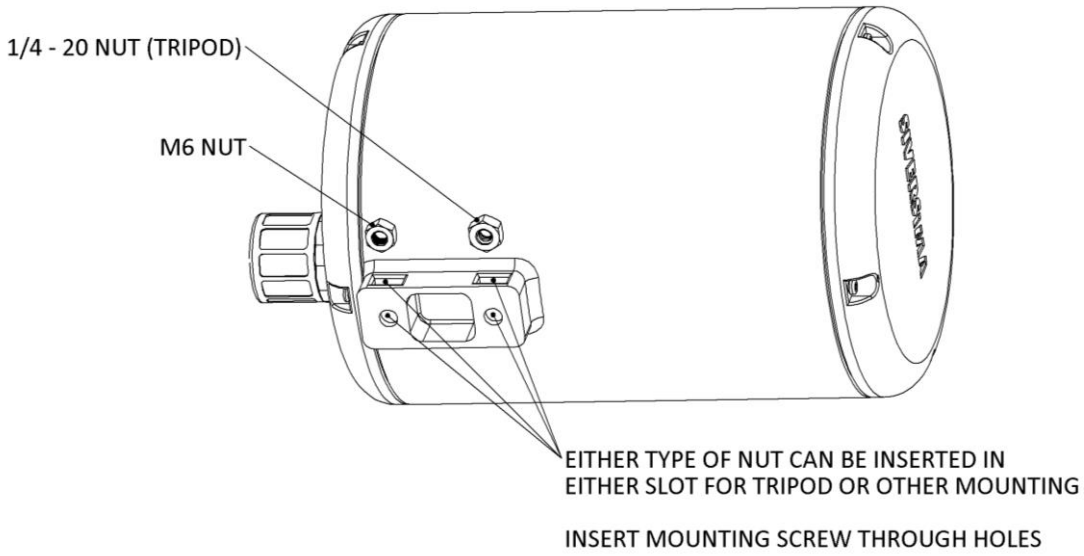
The back of the Radar Unit with the back cover removed is shown in Figure 2. At the top is a 12-terminal block for accessing the digital and analog input and output ports. The terminals are numbered from 1 to 12. At the bottom there are two USB ports. USB2 is used for communicating with a PC and for firmware updates. USB1 port is reserved for future use. There is also a connector for the 12 V power supply.

For evaluation and configuration of the Radar Unit with the GUI, the 12V power supply has to be plugged in and a USB cable has to be connected between the USB 2 port and a computer.

Using the Radar Unit standalone without a computer only requires the 12 V power supply. If the user wishes to turn the radar on/off or trigger a single measurement (more on this in the next section on I/O-Ports), 3.3 V signals are required on the digital inputs.

MOUNTING THE RDK

The radar unit can be mounted to a camera tripod or other surface or bracket using one or two threaded connections using either ¼”-20 nuts (camera tripod standard) or M6 nuts and screws.



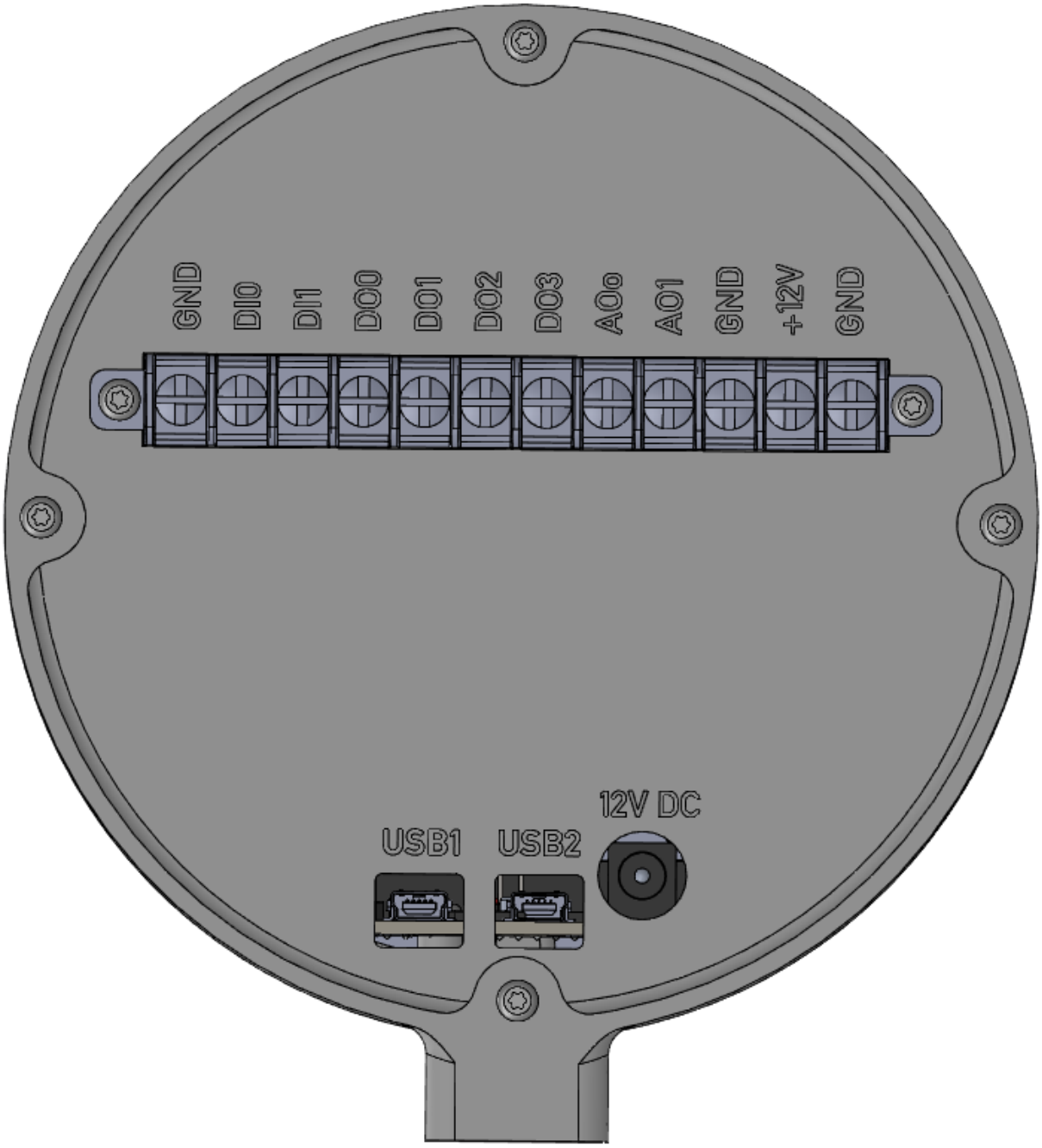


Figure 2 Back of the Radar Unit with the back cover removed and all the connectors exposed.

I/O-PORTS

The Radar Unit contains two digital input ports (3.3V), four digital output ports (3.3 V) and two analog outputs ports (0 V to 3.3 V). The purpose of the ports is to use them for e.g. switching different relays and for distance and level measurements in real-time.

Every output port has its own configuration for detection or distance/speed measurement. The user can configure an output so that only objects within a certain distance/speed window and with an echo that exceeds a user defined threshold will trigger the output. If an object is detected and satisfies the conditions set by the user, the analog output voltage is equal to

$$Analog\ output\ (V) = \frac{Distance - \text{Min}}{\text{Max} - \text{Min}} * 3.3\ \text{V}$$

where Min and Max are the boundaries of the detection range window. If nothing is detected the output is 0. For speed measurements the distance is replaced with measured speed. For a digital output port the output will go high if an object is detected.

The input ports are for triggering a single measurement and switching detection on or off.

The functionality of each port is described in Table 2. More detailed information about their functionality is found in the GUI software section. Each output pin can provide a maximum current of 15 mA.

Table 2 I/O-ports

Pin number	Name	Function	Max Input/Output Voltage	Max Output Current/ Max Current sink
1	GND	Ground		
2	DI0	Digital input for triggering a single measurement at the rising edge.	3.3 V	9 mA
3	DI1	Digital input for turning the radar on/off at the rising edge.	3.3 V	9 mA
4	DO0	Digital output that turns high if an object is detected.	3.3 V	15 mA
5	DO1	Digital output that turns high if an object is detected	3.3 V	15 mA
6	DO2	Digital output that turns high if an object is detected	3.3 V	15 mA
7	DO3	Digital output that turns high if an object is detected	3.3 V	15 mA
8	AO0	Analog output voltage that is proportional to the distance/speed to the detected object.	3.3 V	15 mA
9	AO1	Analog output voltage that is proportional to the distance/speed to the detected object.	3.3 V	15 mA
10	GND	Ground		
11	VIN	External Power Supply. Can be used as separate 12 V supply to the Radar Unit.	12 V	420 mA
12	GND	Ground		

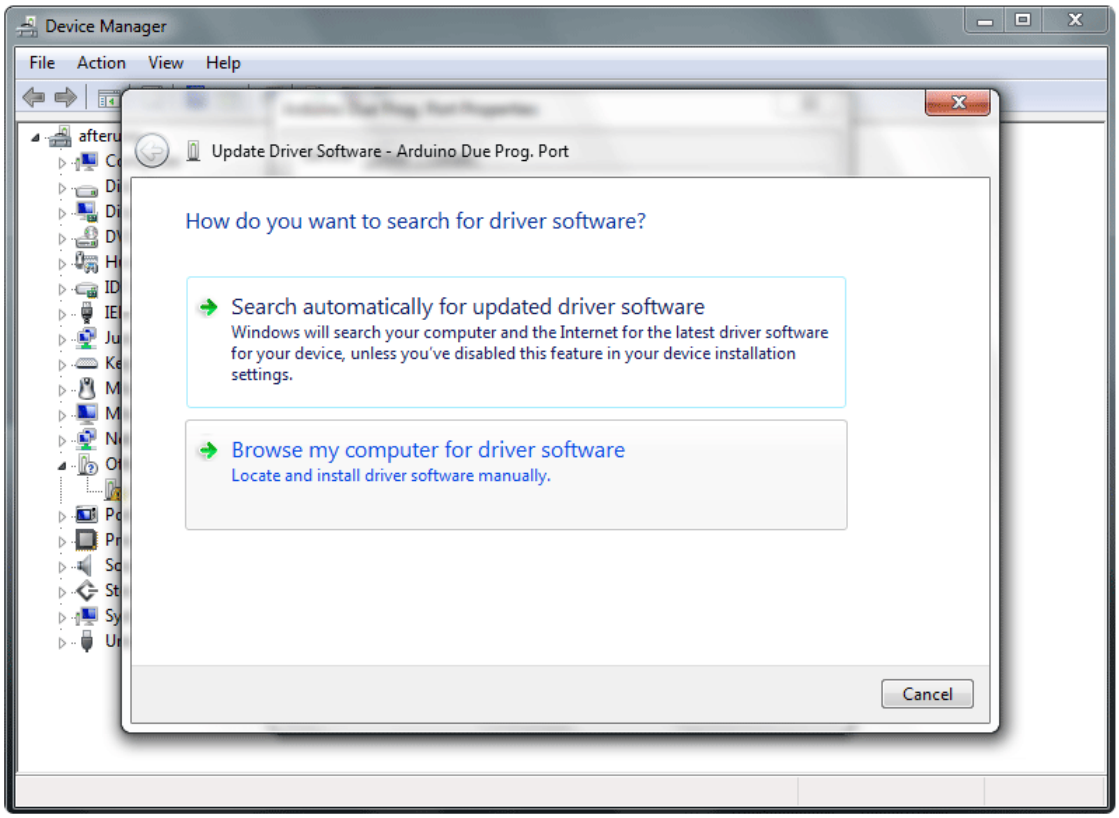
SOFTWARE

DRIVERS INSTALLATION

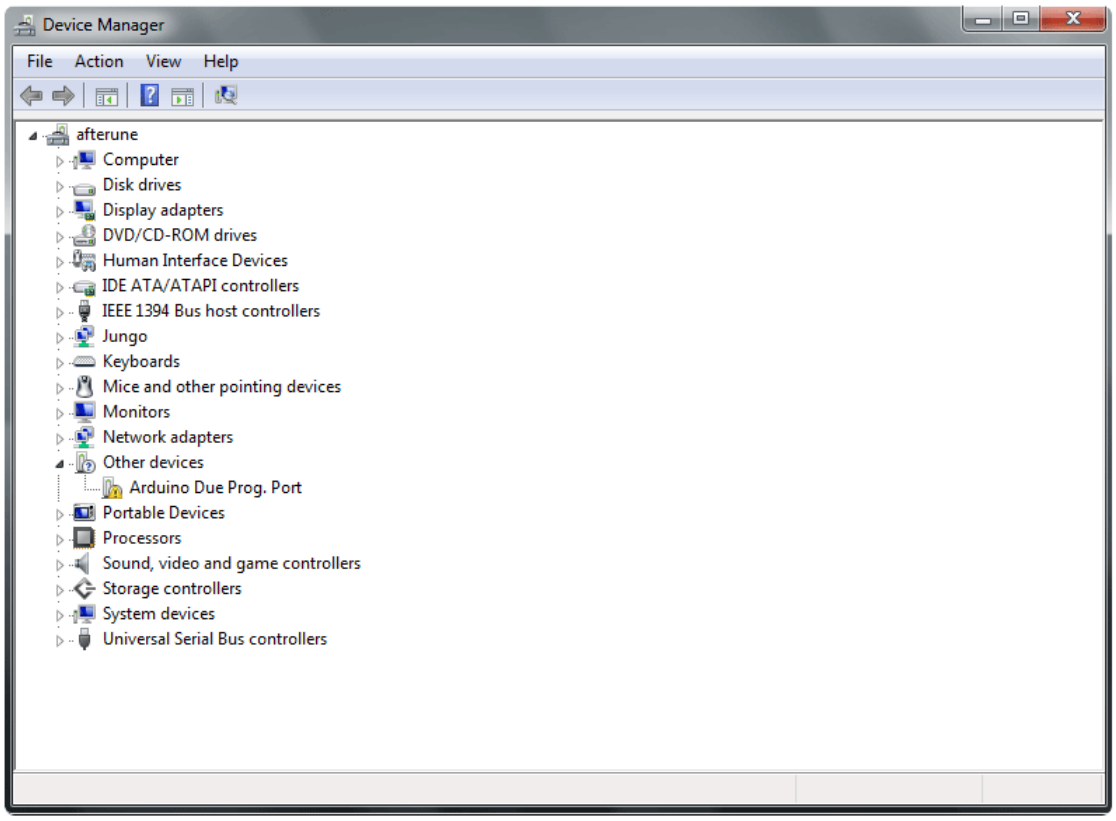
This instruction is valid for Windows 7 and Windows 8 operating systems.

Windows should initiate its driver installation process once the board is plugged in, but it won't be able to find the driver on its own. You'll have to tell it where the driver is.

- Download the RDK Software package from Sivers IMA's webpage - Software Link
- Unzip the RDK Software package
- Click on the Start Menu and open the Control Panel
- Navigate to "System and Security". Click on System, and open the Device Manager.
- Look for the listing named "Ports (COM & LPT)". You should see an open port named "Arduino Due Prog. Port".
- Right click on the "Arduino Due Prog. Port" and choose "Update Driver Software".



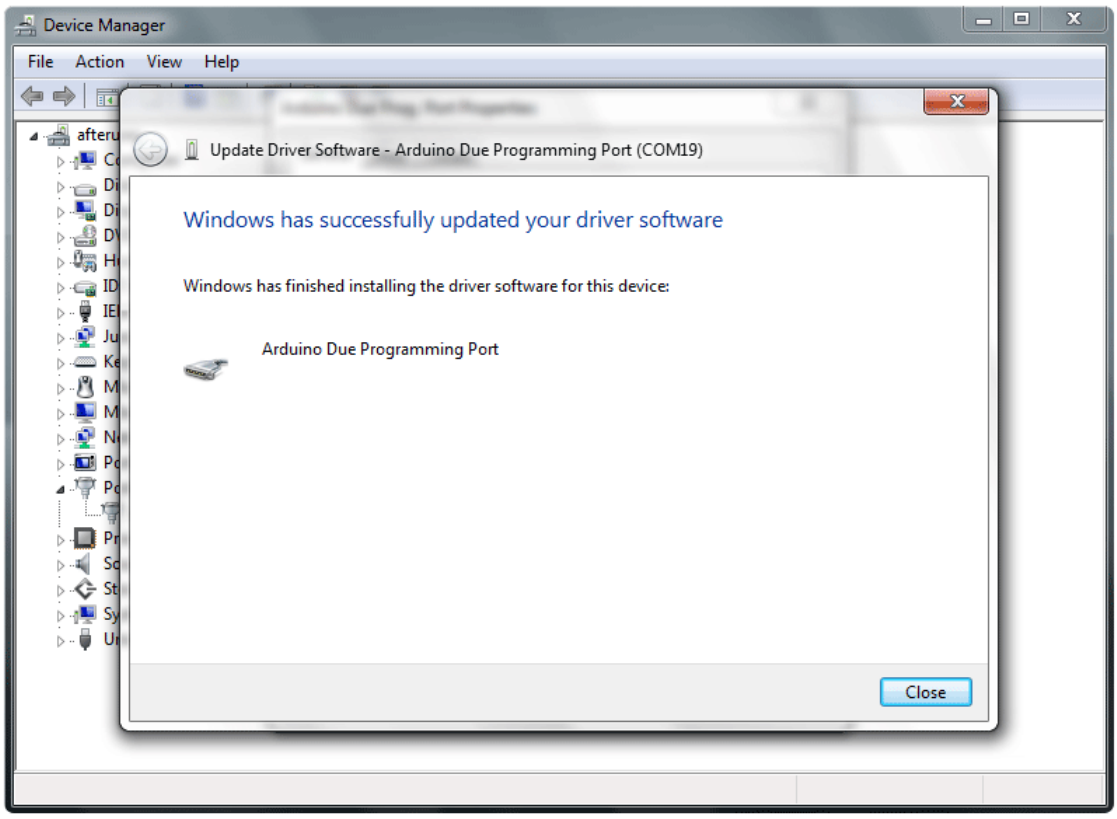
- Select the “Browse my computer for Driver software” option.



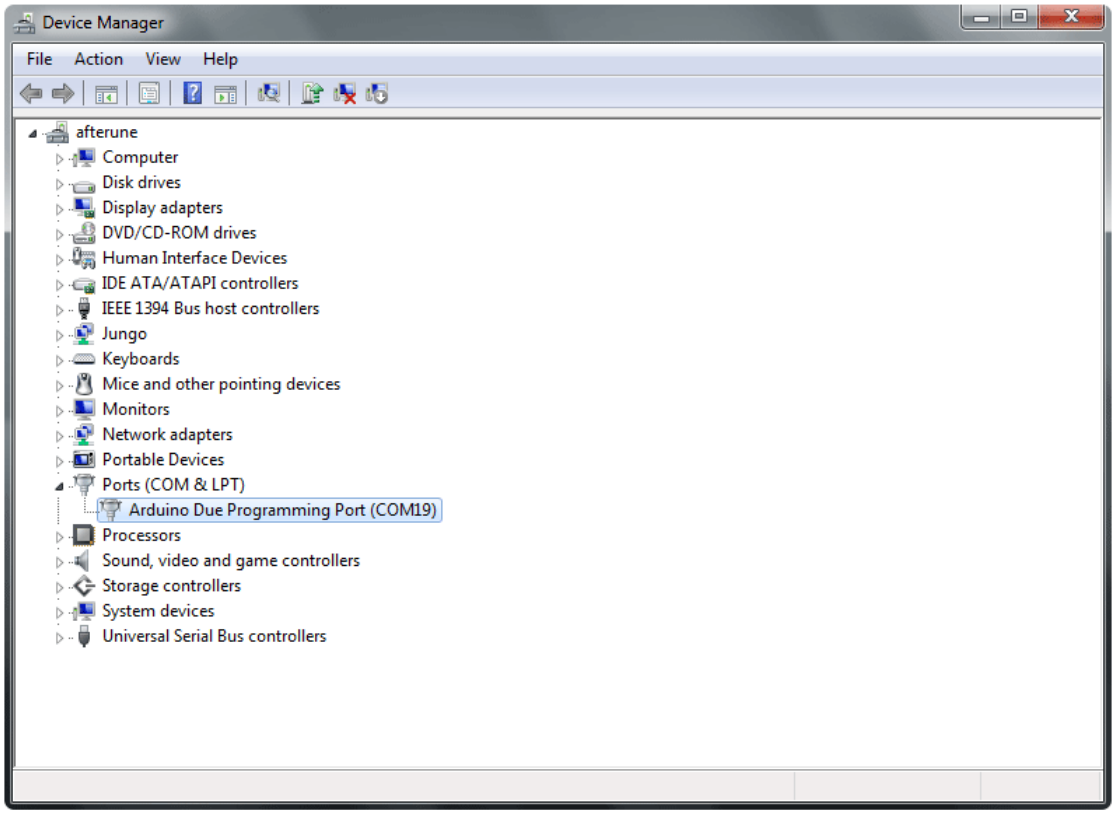
- Navigate to the folder where the RDK Software package was downloaded and unzipped. Locate and select the “Drivers” folder in the main folder (not the “FTDI USB Drivers” sub-directory). Press “OK” and “Next” to proceed.

- If you are prompted with a warning dialog about not passing Windows Logo testing, click “Continue Anyway”.

- Windows will now take over the driver installation.



- You have installed the driver on your computer. In the Device Manager, you should now see a port listing similar to “Arduino Due Programming Port (COM19)”. The number next to COM may differ in your installation.

- 

GUI INSTALLATION

The graphical user interface software that is used for configuring the Radar Unit and testing the radar in real-time is included in the RDK software package downloadable from Sivers IMA's webpage. Click on Setup.exe in the GUI folder and follow the instructions.

After the install is ready there is a folder named Sivers IMA RDK on the start menu (or in the apps section on Windows 8). Press on RDK GUI to start the application. If the drivers were correctly installed the screen at startup should look like in Figure 3 and the status bar at the bottom should say that the Radar Unit is connected. If it says that it is not connected, check the connection and make sure that both USB and 12 V are plugged in. If the application still cannot find the Radar Unit check that the drivers are installed and eventually redo the steps in the drivers installation section.

Figure 3 RDK screen at startup.

STEP BY STEP GUIDE TO A BASIC MEASUREMENT

A step by step guide for measuring the distance to an object at different positions in a room is presented. Performing the measurement is a good idea for a user who wants to validate the functionality and performance of the kit, or just wants to test the kit before digging in to all the details.

- Position the Radar Unit on e.g. a tripod so that the Radar Unit is at least ½ meter above a table or ground. It is important that there is nothing above or below close to the radar. Make sure that the radar is pointing at a wall about 4-5 meters away and that there are no objects between. Even though the antenna has a narrow lobe, the radar can still catch objects outside the main beam.
- Start the RDK GUI. The screen at startup should look like in Figure 3. If it says that the Radar Unit is not connected, check the connection and that the drivers are installed.
- Detection is switched on and off with the button at the top left. If detection is off, switch it to on (The icon changes to a radar with a transmitted and reflected wave).
- Use the settings shown in Figure 4 and press apply.
- Press run in the menu bar. The graph should now look similar to Figure 5 where it is very clear that the wall is located 3.4 m away.
- Find some object with a metal surface and whose height and width is about 10-20 cm. Place the object about 1 meter in front of the Radar Unit at the same height and look at the graph. You should now

also see a peak at 1 meter similar to the graph in Figure 6. Note that the radar still sees the wall even if you have placed something in front of it.

- Move the object back and forth and see how the peak travels along the x-axis. In Figure 7 the object is positioned 2.3 m away, and in Figure 8 2.9m from the radar. Even if it is very close to the wall the radar can still distinguish it from the wall. Note that the reflection from the wall now results in the highest peak. Even though the wall is further away, it has a larger area which now compensates for the slightly longer distance and its less reflective material.

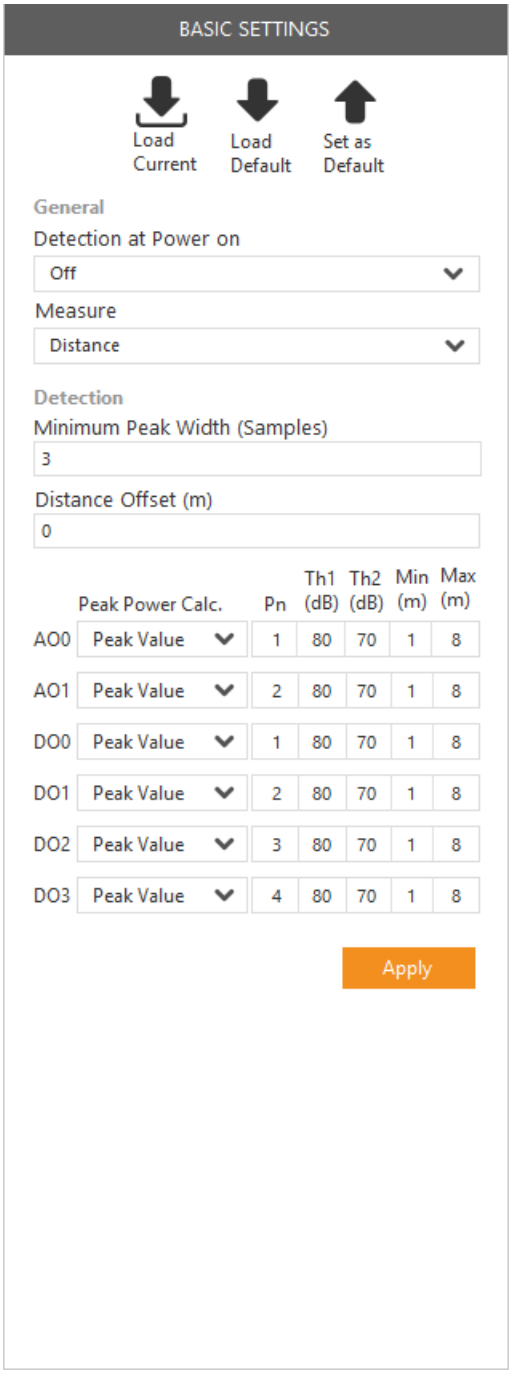


Figure 4 Settings used during the measurement.

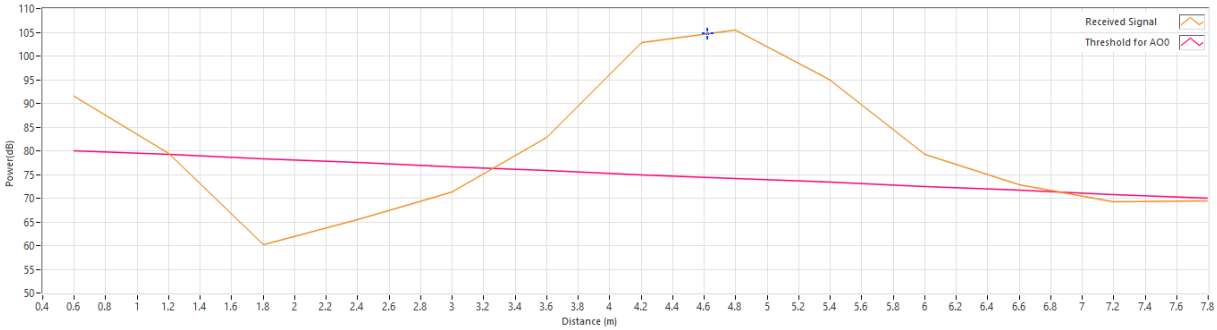


Figure 5 The received echo signal with only the wall 4.6 m away.

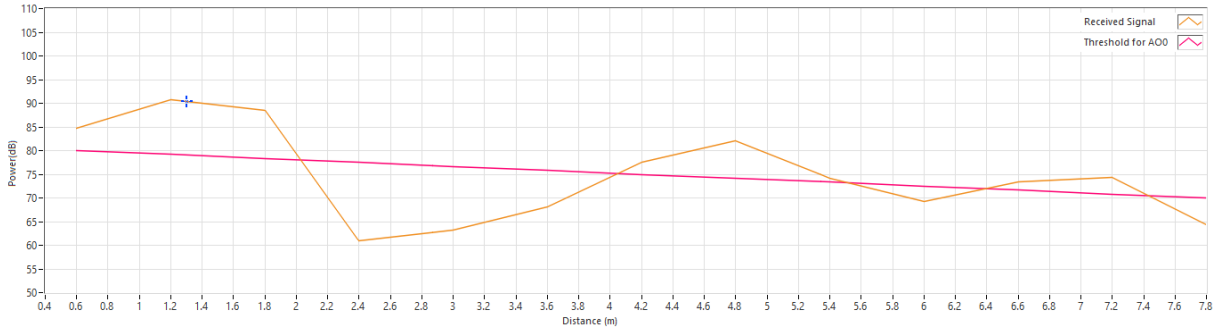


Figure 6 Wall and object 1.3 m away.

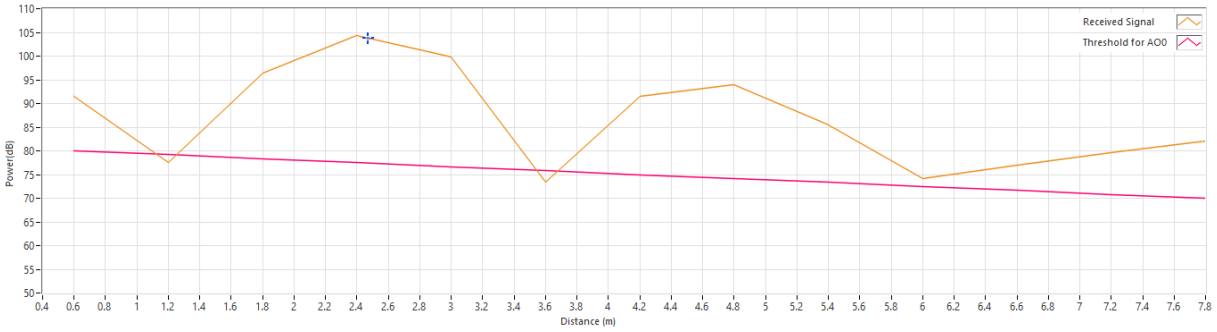


Figure 7 Wall and object 2.3m away.

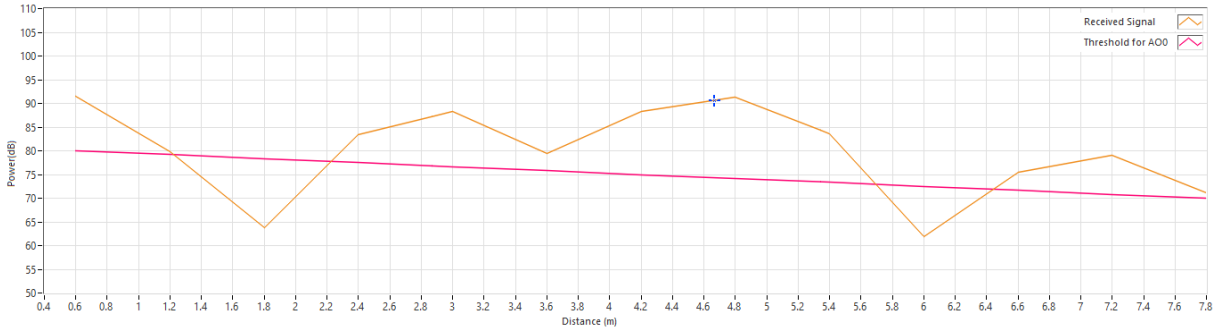


Figure 8 The object 2.9m away and the wall is still detected.

GUI

With the Graphical User Interface (GUI) the user can configure the Radar Unit, e.g. detection thresholds and detection range window, and monitor the received signal and values of the Radar Unit outputs. Radar parameters such as frequency, bandwidth and sweep time can also be configured.

OVERVIEW

A screenshot of the GUI during Run mode is shown in Figure 9. The GUI is built up of a menu bar, a status bar at the bottom and four different subpanels; advanced settings (hidden as default), basic settings, received signal and A&D outputs.

The advanced settings are hidden as default and should only be changed by a user that has good knowledge of radar technology. The basic settings are for changing measurement and detection settings.

Detection can be switched on or off with the button that pictures a radar and is positioned in the menu bar at the top left. If detection is switched on, the “Run” and “Run Once” buttons will be enabled. By pressing run the received signal can be seen in the panel with the graphs, received power vs. either distance or speed. To the right is the panel with the Radar Unit output values. For the analog outputs, both the voltages and distances to the objects that triggered the outputs are shown. For the digital outputs, voltages are replaced with either high (3.3V) or low (0V).

Figure 9 The GUI in run mode with advanced settings shown.

CONFIGURING THE RADAR UNIT

BASIC SETTINGS

In the basic settings the user can change measurement methods and detections settings. Depending on the application and range different settings are usually preferred. Every parameters function and how it affects the detection are explained below.

Detection at Power on (On/OFF)

When switched to on, detection is automatically turned on every time the radar is powered on. Default is off which means that the detection has to be manually switched on with either the GUI or the digital input (DI1) that controls this switch. Even if the detection is turned off, a single detection can still be triggered with DI0.

Measure (Distance/Speed)

Used for changing between measuring distance or speed. Default is distance.

Minimum Peak Width (Samples)

A peak can be defined by one local maximum and two local minimums. If the number of points between the two minimums (including the minimum points) is less than the minimum peak width then the peak is rejected and basically considered as noise or clutter. Default is 3.

Peak Power Calculation (Peak value/Peak height)

Determines how the power or intensity of every classified peak is calculated. If switched to “Peak Value” only the absolute value at the peak position is registered and compared to the threshold. “Peak Height” means that the value between the peak (maximum) and the two local minimums surrounding it is compared to a threshold value. The difference between the two methods is illustrated in Figure 10 where the peak value is equal to P0 and the peak height is equal to (dP1 + dP2) / 2. Different thresholds have to be used for the different methods. The peak width method can be used with benefit if the user has little knowledge of the noise characteristic or the path loss of the signal because only the peaks that stand out from the noise are detected. The drawback with this method is that false detections may occur when noise peaks arise due to surrounding notches. Default is “Peak Value”.

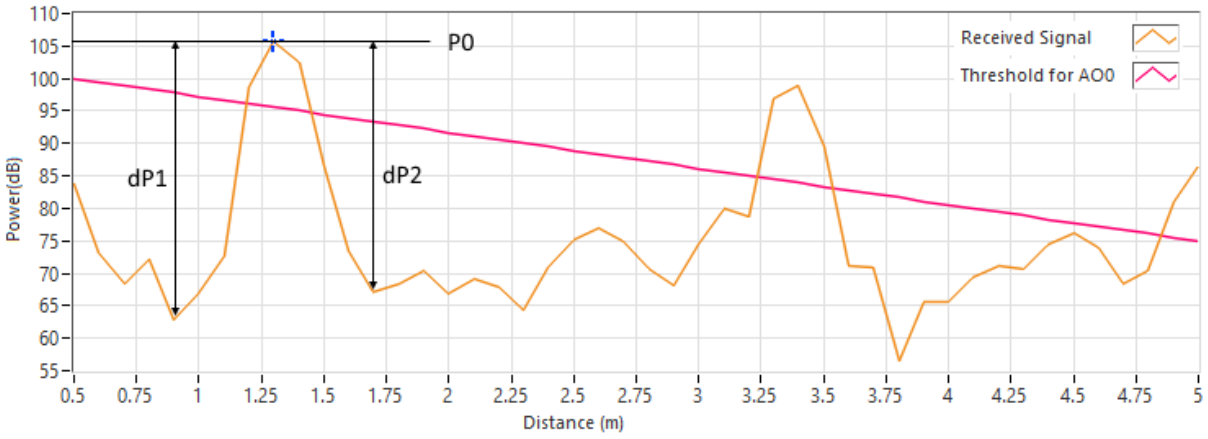


Figure 10 Illustration of peak power calculations. Peak value is equal to P0 and the peak height is equal to (dP1 + dP2) / 2.

Distance offset (m)

A distance offset can be added to the measured distance. Both negative and positives values are accepted. Default is 0.

PN

Here the user can set which peak number (Pn) inside the detection range that should be analyzed and compared to the threshold. The peaks are numbered from highest peak to lowest peak, and in this case the peak intensity is calculated as the peak value, i.e. the absolute value at the peak position. This function is useful if the user knows that there is some clutter very close that results in a high peak and should be rejected. Also different peak numbers for the different outputs can be used if multiple objects are to be detected within the same detection range. Default is 1.

Th1 and Th2 (dB)

The threshold used for detection of peaks is defined by two points Th1 and Th2. Th1 is the threshold in dB at the minimum distance in the detection range and Th2 is the threshold at the maximum distance. For every other distance between the endpoints the threshold is linearly interpolated. Due to path loss the received power decreases with distance, and thus it is usually recommended to have a threshold with a negative slope. Default is a threshold from 90 dB (Th1) to 60 dB (Th2).

Min and Max (m or km/h)

The detection range is defined by a min and max value. When a detected object triggers the analog output the voltage will be proportional to the difference between the distance (or speed) and the min value, i.e. for e.g. distance

$$Analog\ output\ (V) = \frac{Distance - \mathrm{Min}}{\mathrm{Max} - \mathrm{Min}} * 3.3\ \mathrm{V}$$

If nothing is detected in the range the output is 0. Default detection range is 1 to 10.

ADVANCED SETTINGS

The advanced settings are hidden as default and should only be changed by a user that has good knowledge of radar technology.

The Radar Unit is delivered with frequency settings that are in compliance with the regulations for the 24 GHz (24 – 24.25 GHz) ISM band defined by ITU-R. Individual countries' use of the band may differ due to variations in national radio regulations. If the user changes the frequency settings, the user is solely responsible for compliance with all legal and regulatory requirements, and Sivers IMA has no responsibility whatsoever.

Center Frequency (GHz)

The center frequency of the swept frequency band. Default is 24.125 GHz

Frequency Span (GHz)

The width of the swept frequency band. The range resolution of the radar is inversely proportional to the frequency span. Default is 0.25 GHz.

Frequency Sweep points

The frequency sweep is stepped with a uniform set of discrete frequency points. This value can only be a power of 2 and the default is 512.

Frequency Sweep time (ms)

Sets the total time for a complete sweep. This time should be chosen long enough to allow a sufficient time at each frequency point. The default is 75 ms.

Number of Frequency Sweeps

Defines the number of frequency sweeps to be performed when triggered. The measurement of the IF signal is averaged over the number of sweeps. The default is 1.

Sweep Type (Sawtooth/Triangular)

Defines the type of sweep to be performed. The type sawtooth is a sweep of linearly increasing frequency. When the highest frequency is reached, the sweep restarts at the lowest frequency. The type triangular is a sweep of first linearly increasing frequency and then linearly decreasing frequency. The sweep then restarts with an increasing frequency.

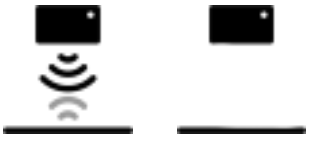
STORING THE CONFIGURATION

When clicking apply the settings are written to the Radar Unit and immediately applied in the detection, but the settings will not be permanent unless they are stored in the flash memory of the Radar Unit. Every time the Radar Unit is rebooted it will load with some default settings. If the user wants to make the currently used settings permanent and always loaded as default at startup the button “Set as default” have to be clicked. The basic settings and advanced settings are separated and can be both changed and stored individually.

The basic default settings can be loaded to the panel by clicking on the “Load default” icon, but they are not applied until apply is pressed. For the advanced settings, the settings cannot be loaded without applying them at the same time.

SWITCHING DETECTION BETWEEN ON AND OFF

The button at the top left in the menu bar (see Figure 9) switches the detection between on (Figure 11a) and off (Figure 11b). By switching the detection to on, the “Run” and “Run Once” will be enabled and the user can display the received echo signal and the voltages of the output ports.



(a) (b)

Figure 11 Switch button for switching detection between on (a) and off (b).

DISPLAYING THE RECEIVED SIGNAL AND RADAR UNIT OUTPUTS

When detection is switched on the run buttons will be enabled. By pressing “Run” on the menu bar the GUI starts collecting information from the Radar Unit and the received echo signal and output values are updated in

real-time. All the settings can be changed on the fly even when in run-mode. By pressing stop the GUI stops collecting information. If the user wishes to only trigger a single measurement the “Run Once” button can be pressed.

In the received signal panel there are two graphs. The upper graph shows the received echo signal for the combined detection range of all the outputs. In the lower graph the displayed range can be changed by choosing an output. The graph will only be plotted for the range of the chosen output and the threshold for the same output will also be displayed. If an object is detected the corresponding peak will be marked with a blue cursor.

In the A&D outputs panel the values of the Radar Unit outputs are displayed. If an output goes high (or outputs an analog voltage) the distance or speed to the object that triggered the signal is also shown.

UPDATING THE RDK FIRMWARE

When new firmware updates are released they will be available on the homepage for downloading. Software Link. To update the firmware, press the firmware icon on the menu bar to open the firmware dialog shown in Figure 12.

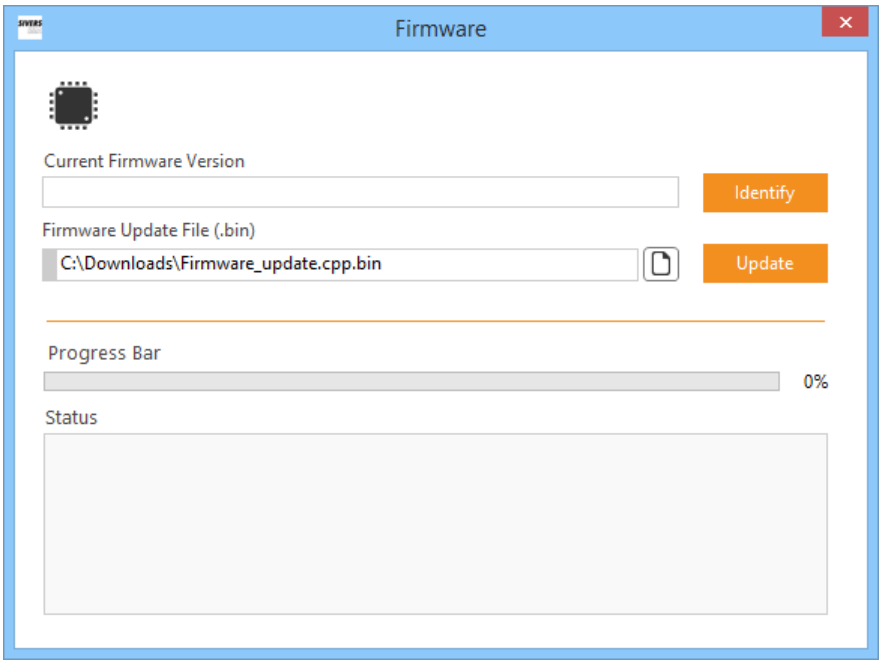


Figure 12 Firmware update dialog window.

Browse to the firmware file and press update. You will get a dialog box prompting for you to select the correct communication port, see Figure 13. If you are unsure of which port is the correct one, go to the device manager as described in the drivers installation section and check which port the “Arduino due programming port” has been assigned. Note that the same port (USB2) is used for updating the firmware and communicating with the radar unit. USB1 is reserved for future use.

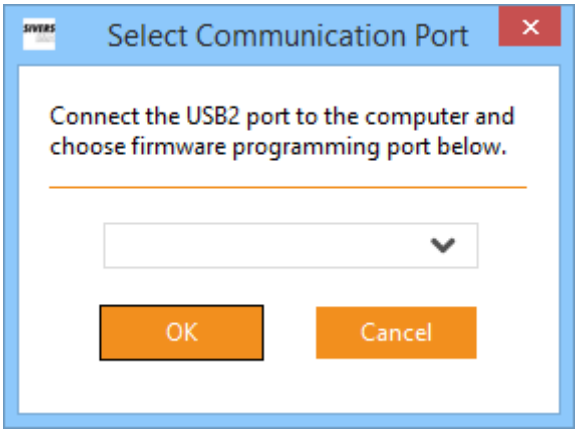


Figure 13 Dialog box for selecting communication port for the firmware update.

USAGE WITHOUT THE GUI

When the user has configured and tested the kit with the GUI it will normally want to deploy the Radar Unit somewhere for real world measurement or detection of objects. In this case only a 12V power supply is needed.

POWER REQUIREMENTS

- 12 V power supply
- Power consumption: < 1W

CONTROLLING THE RADAR UNIT

The radar detection is controlled with the two digital input ports (pin 2 and pin 3). Detection can be turned on or off with pin 2. The Radar Unit registers an event at the rising edge of the signal. Triggering this pin will always make a transition to the opposite state (from on to off and vice versa). This switch can also be changed with the GUI. If detection is turned off a single measurement can be triggered with pin 3 and the outputs will stay constant until the next trigger or if detection is turned on.

USING THE OUTPUT PORTS

The digital outputs can be used for digital control. If distance or level measurements are carried out, the analog outputs should be used. Note that each pin can provide a maximum output current of 15 mA. For more information about configuring the ports see the GUI section.

TIPS FOR RELIABLE AND ACCURATE MEASUREMENTS

- Position the radar so that no objects, including the ground and ceiling, are close to the radar, unless of course these are the objects you want to measure.

TROUBLESHOOTING

The GUI says that the Radar Unit is not connected, but I have connected it to my computer.

Make sure that you have connected the USB cable to USB 2 (not USB 1) on the Radar Unit and that the 12 V power supply has been plugged in. Also make sure that the drivers have been correctly installed. Click on the Start Menu and open the Control Panel. Navigate to “System and Security”. Click on System, and open the Device Manager. Look for the listing named “Ports (COM & LPT)”. You should see an open port named “Arduino Due Prog. Port”. If there is an exclamation mark like in the figure on page 6, then the drivers have not been correctly installed and you should redo the steps in the drivers installation section. If you have done everything above and still have problems, try rebooting the Radar Unit and the GUI. A good idea is also to reboot your computer if you have not done that after installation of the drivers.

The displayed values in the graphs and output values are not the same that I have configured or displayed correctly.

If you are using other regional and language settings than English, there might be some issues with displaying the correct values, especially when a decimal separator is used. One method is to just change the regional and language format to English:

1. Open the Control Panel (icons view) in Windows 7 or Windows 8, and click/tap on the Region and Language (Windows 7) or Region (Windows 8) icon.

2. Under the Formats tab, select English (United States) from the Format drop down menu, see screenshot in Figure 14 below.

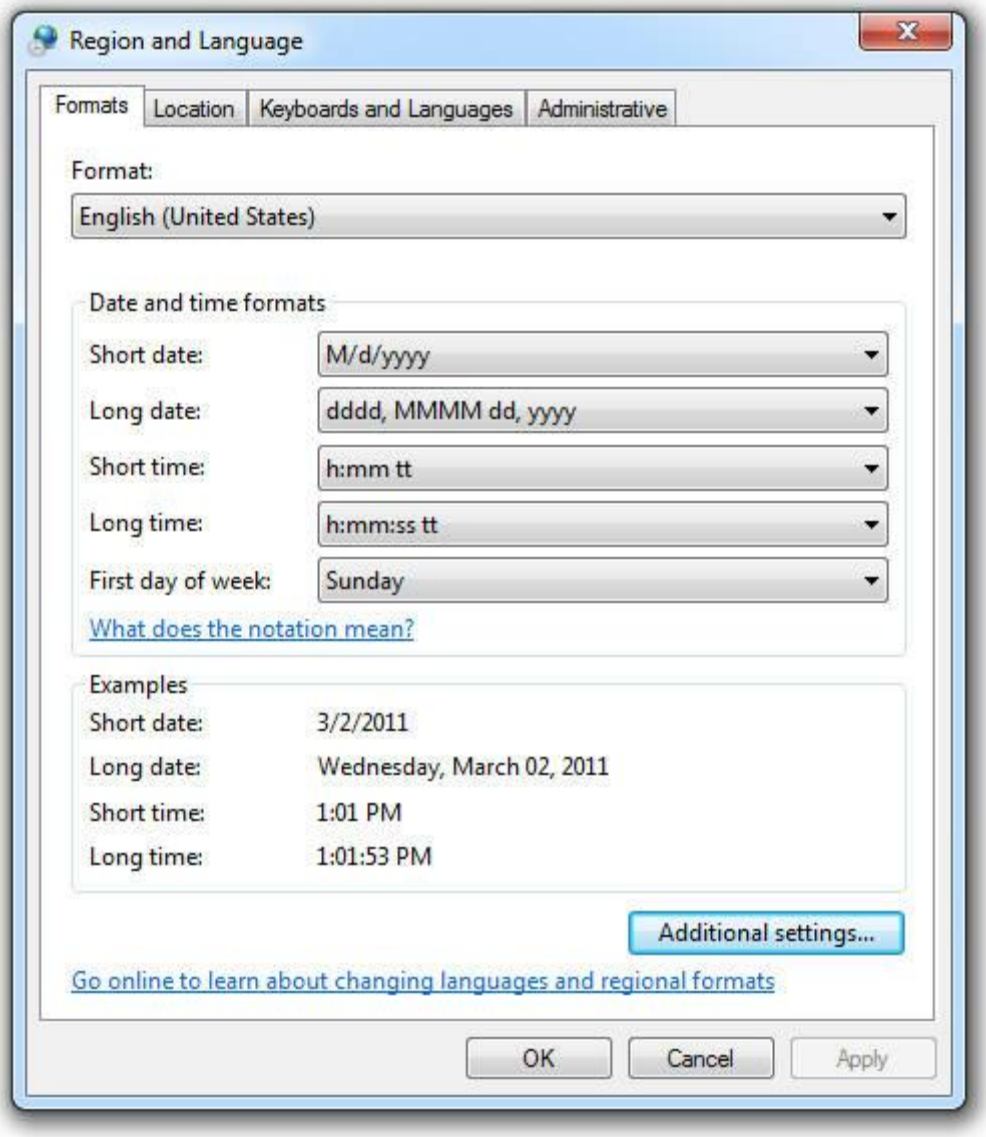


Figure 14 Formats tab in the regional and language options.

If you don't want to change the regional settings (as this will affect all applications and windows) or the fist fix doesn't work, there is a second fix:

1. Go to "C:\Program Files\SiversIMA RDK\".
2. Right click on "SiversIMA RDK.ini", navigate to "Open with" and click on notepad.
3. Add the following on a new line at the end of the document (see screenshot in Figure 15):
   "useLocaleDecimalPt=False"
   Note that the rest of the text might differ from what is seen below. Do not edit anything else.
4. Save the file and close it.

```
[FMCW RDK]
server.app.propertiesEnabled=True
server.ole.enabled=True
server.tcp.paranoid=True
server.tcp.serviceName="My Computer/VI Server"
server.vi.callsEnabled=True
server.vi.propertiesEnabled=True
WebServer.TcpAccess="c+*"
WebServer.ViAccess="+*"
DebugServerEnabled=False
DebugServerWaitOnLaunch=False
useLocaleDecimalPt=False
```

Figure 15 ”SiversIMA RDK.ini” content after adding the line at the end.

I cannot install the software with the provided installer

Make sure that your user account has permission to install software. If you are unsure, right click on Setup.exe and click “Run as administrator”. Also make sure that the file is not broken by downloading the installation package one more time.

If the problems persist, contact Sivers IMA and provide us with the error information. We will help you with getting it installed.

APPENDIX 1 – RDK DATA SHEET

Radar Development Kit

SIVERSIMA

Features

- 24 GHz ISM band
- 22 dBi internal antenna
- USB interface
- 12 V power
- Programmable analog and digital connections

Description

Sivers IMA's Radar Development Kit (RDK) is intended for customers who want to either quickly evaluate the possibilities of FMCW radar or cost efficiently implement the features of FMCW radar sensors in their products.

The kit consists of a small case with a 24 GHz FMCW radar (Sivers IMA RS3400K) and a microprocessor board for controlling the radar and signal processing of the received echo signal for excellent accuracy and range resolution. The RDK comes bundled with a GUI that can be used for evaluating the radar and for configuring e.g. detection thresholds and distance. Different applications usually require different settings. Some typical applications are level measurements in tanks and security in the automation industry.

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Radar Development Kit

SIVERSIMA

Specifications

Parameter	Min	Max	Unit
FMCW center frequency	24	25.5	GHz
FMCW frequency span	0	1.5	GHz
Update rate	0	10	Hz
Detectable distance for RCS = 1 m^2 *	0	TBD	m
Detectable speed	0	215	Km/h
Total power consumption	-	1	W

* * Radar cross-section (RCS) is a measure of how detectable an object is with a radar. A larger RCS indicates that an object is more easily detected. For example a perfectly conducting sphere of projected cross sectional area 1 m^2 (i.e. a diameter of 1.13 m) will have an RCS of 1 m^2

Operating Conditions and Maximum Ratings

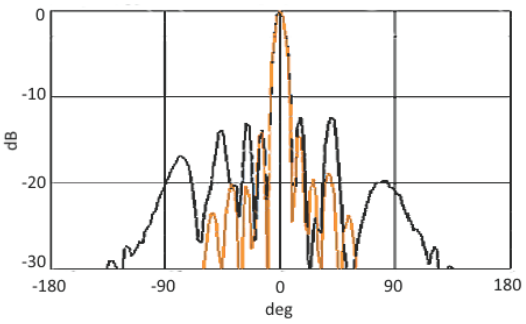
Parameter	Min	Max	Unit
Digital input voltage (DI0 – DI1)	0	3.3	V
Digital input current (DI0 – DI1)	0	9	mA
Digital output voltage (DO0 – DO3)	0	3.3	V
Digital output current (DO0 – DO3)	0	15	mA
Analog output voltage (AO0 – AO1)	0	3.3	V
Analog output current (AO0 – AO1)	0	15	mA
12 V Power supply	0	12	V
Operating temperature	0	70	° C
Output power	5	15	dBm

Antenna Characteristics

Directivity: Min 22 dBi, Max 23 dBi
3dB-beamwidth: Min 8.5 deg, Max 9.5 deg.

Antenna Pattern at 24.75 GHz

Orange - Eplane
Black - H-plane



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